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# Network topology descriptions in optical hybrid networks

Status of This Document
This document provides information to the Grid community regarding the context for the work in the OGF NML-WG. Distribution is unlimited.



Abstract
The NML-WG goal is to define a schema for description of optical hybrid network topologies. This schema is to be used by lightpath provisioning application to exchange topology information intra and inter domain.
This document constitutes the deliverable 1 of the working group. It provides a detailed overview of the framework in which the working group operates, detailing the already existing topology schemas and providing the basis for the integration of the various projects.

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## 1. Introduction

As e-Science applications have become more distributed in nature and can take advantage of the various R&E computing Grids, they have also started to have more specific requests on the performance and services offered by the underlying networks. If data moves from one location to another, from one Grid cluster to another, the time the transfer takes – the *bandwidth*, the variation in arrival time at destination - the *jitter,* or the time for a packet to get to destination – the *delay,* all become critical components to be accounted for in the computational model of the application.
To provide applications with guaranteed, reliable and reproducible network services the R&E networks around the world have started to offer *lightpaths* to end users. Lightpaths are dedicated circuits in the network of which the application is the sole user, and consequently has control on the traffic and no competition for network resources; this results in a more reliable network service.
The trend is clear looking at the network architecture design in many of the NRENs in the last years. These networks have moved to a so-called *hybrid* model: routed IP services for traditional network use are complemented by the novel concept of lightpaths. Just to name a few we can think of the SURFnet6 network in the Netherlands, or the European network GEANT2 with its Premium IP service or the Internet2 network in the USA with the HOPI project.

Lightpaths are often called *lambdas* as they are provisioned for the end user as dedicated wavelengths in the DWDM network. Analogous to computing Grids, the goal is to have *lambda Grids* in which network connections are created ad-hoc when needed and reliably. To achieve this, there are two important aspects that still need a solution and are being addresses by the research community: a true dynamicity in the setup of paths and the extension of the path beyond a single domain to a true multi-domain setup.
If the creation of a new circuit takes too much time and it requires manual intervention applications cannot interactively and in real time make use of them. If lightpaths are confined to a single network domain under the same administrators applications cannot effectively communicate. Both issues are tackled by the provisioning system under development in all the R&E networks.

Interoperability of provisioning systems requires communication of network information among them. Network topologies, network capabilities, scheduling information, and much more, need to travel between domains. This working group focuses on the definition of a standardized model for network information exchange to be used in Lambda Grids for the setup of lightpaths.
In following sections we will give an overview of the existing schema for topology description in use within the international research community. This list does not intend to be exhaustive, but intends to set a ground for the definitions of the necessary elements in a standard Network Markup Language.
Drawing on the experiences in the current models we follow with the overview of the required components in a standardized schema.

## 2. NDL – Network Description Language

NDL[1] is data model developed by researchers at the University of Amsterdam to describe (computer) networks. NDL comprises of a series of RDF schemas that categorize information for network topologies, network technology layer, network devices configuration and capabilities, network domain abstractions.
The main use-cases so far have been generation of network maps, lightweight offline path finding and more recently multi-layer path finding, and network topology information exchange.
NDL has been used primarily in the research community in the Netherlands: UvA, SARA and SURFnet. It also been applied to the GLIF Optical Exchange Points (see: http://www.glif.is).

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### 2.1 RDF and Semantic Web

One of the main differences of NDL over other topology schema is its use of RDF – Resource Description Framework – as language syntax and the grounding of the model in the Semantic Web framework.
The extensive reasons for the RDF choice instead of XML are explained in document available in the NML-WG project web site (ref: http://forge.ogf.org/sf/go/doc14257?nav=1). To roughly summarize this document we can say that NDL chooses RDF because:

- It allows easier exchange of information between independent domains.
- It is easily extendible and it allows integration of independent data models developed in other fields, by other researchers

Several tools that consume RDF data are publicly available and make the use of this syntax straightforward.

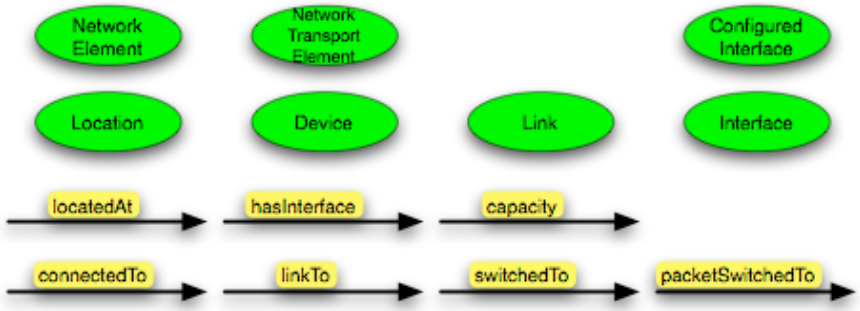
### 2.2 NDL schemas

The Network Description Language (NDL) is a modular set of schemas, defining an ontology to describe computer networks:

- The topology schema describes devices, interfaces and connections between them on a single layer;
- The layer schema describes generic properties of network technologies, and the relation between network layers;
- The capability schema describes device capabilities;
- The domain schema describes administrative domains, services within a domain, and how to give an abstracted view of the network in a domain;
- The physical schema describes the physical aspects of network elements, like the blades in a device.

#### 2.2.1 NDL topology schema

The classes and properties in the topology schema describe the topology of a hybrid network, without detailed information on the technical aspects of the connections and their operating layer. The idea is that that through this lightweight schema we can provide an easy toolset for basic information exchange and path finding.

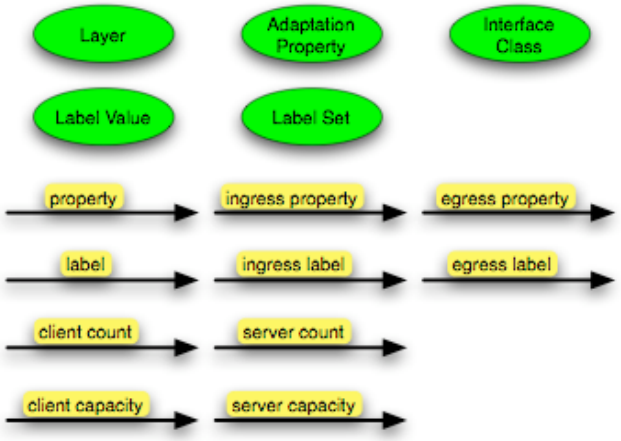



The *linkTo* property corresponds to a link connection or edge, while the *connectedTo* property corresponds to a network connection or a path. linkTo and connectedTo describe external connections, between two devices.
The *switchedTo* and *packetSwitchedTo* properties define internal connections within a device: the configuration of a device.

The immediate applications of the topology schema are visualization of network maps and input to path finding systems.

### 2.2.2 NDL layer schema

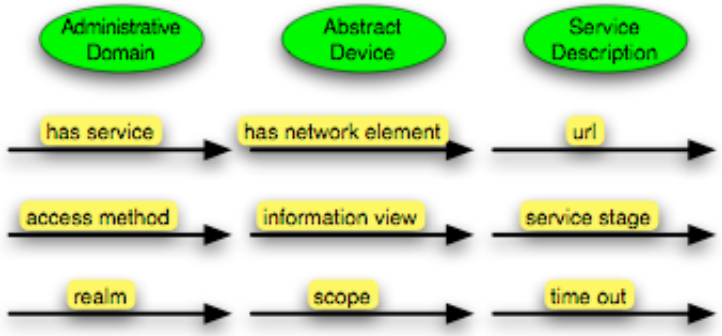
The topology schema defines network topologies on a single layer. The NDL layer schema allows applications to describe multi-layer networks, like hybrid networks.
The NDL layer schema is based on a formal model, which uses ITU-T G.805[2] functional elements and the concept of labels as described in GMPLS[3].




A Layer is a specific encoding in network connection; most Layers have a associated Label Set that defines which channels are used to make switching decision in a device. For example, the label on the wavelength division multiplexing (WDM) layer is a wavelength.
Each Interface instance operates at a certain Layer. When data from one layer needs to be encapsulated in another layer we use Adaptation. The client (layer) and server (layer) refer to the Layers before and after the Adaptation.
This layer schema does not define actual adaptation functions, but instead provides a common vocabulary to describe technologies, layers and the relation between layers. We make use of the layer schema in a tool for path finding across multiple layers.

### 2.2.3 NDL domain schema

The NDL domain schema defines administrative domains and the services offered by a domain. It allows network operators to provide an abstracted view of their domain to neighboring domain, rather than the full topology.




The current schema only describes administrative domains, not owner domains. This was done to keep the schema as simple as possible.
An important concept in the domain schema is that of Service Descriptions. Service descriptions allow domains to point applications to the (web)services they offer.

The idea is that domains publish static information in NDL, and provide a webservice for dynamic information or more confidential data, like reservation requests. Furthermore, different domains will have different opinions on what is ``static'' and ``non-sensitive''.

## 3. PerfSONAR

## 4. GEANT2

## 5. Toward a standard schema

We described in the preceding sections (some of) the current efforts in the definition of suitable data models for network topology information exchange. It is obvious that the convergence towards a common standard model facilitates its adoption from the various provisioning systems that in turn can more easily interoperate.

### 5.1 Usecases

It has been suggested in the WG that standard network description language would be employed for:

- Path finding
- Visualization
- Asset management (inventory of network devices)
- Network measurements

In the following sections we provide a more detailed description of these usecases and the role the standard NML will play in them.

Paola Grosso 6/25/07 3:50 PM
**Comment:** *I must say that personally I am not in favor in a very general scope for this language, as I fear this would make convergence more difficult. For example network measurements are already described by the schemas in the NM-WG. Also, why do we need asset management as usecase for the data model whose goal is primarily focused with the management of lightpaths? I leave this in any case so that subsequent authors can*

#### 5.1.1 Path finding

Finding lightpaths is the most interesting and most relevant application for the NML.
In general there are two ways in which inter-domain paths can be found:

- In-band, letting the network devices autonomously negotiate among themselves. This is for example what a GMPLS network would do;
- Out-of-band, letting the provisioning system exchange topology information and perform the calculation.

The GMPLS approach requires network domain to be willing to let information about their internal topology to be autonomously and seamlessly be exchanged at the domain boundary. Network engineers and administrator can exert less control on their own resources. For this reason many providers prefer an offline approach in which the information on the network is exchanges by the mean of predefined schemas and there is more control on the data that is exposed externally. In this case the NML finds its best applicability.

Which data is necessary to expose to find a lightpath?
We need:

- Topology information – which devices connect to which devices
- Capability information – what kind of services are available between connecting interfaces
- Scheduling information – (this might be optional) – what are the available timeslots for the requested service

**5.1.2 Visualization**
**5.1.3 Asset management**
**5.1.4 Network measurements**

## 6. Conclusions

## 7. References

[1] – NDL web page URL: http://www.science.uva.nl/research/sne/ndl
[2] ITU-T Recommendation G.805: Generic functional architecture of transport networks, URL: http://www.itu.int/rec/T-REC-G.805/en
[3] E. Mannie, “Generalized Multi-Protocol Label Switching (GMPLS) Architecture”, URL: http://www.ietf.org/rfc/rfc3945.txt